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# PATENT SPECIFICATION

594,770



Application Date: April 27, 1944. No. 7899/44.

Complete Specification Accepted: Nov. 19, 1947.

## COMPLETE SPECIFICATION

### Improvements in or relating to Electric Motors of the Oscillating Armature Type.

(Communication from THE MARTIN BROTHERS ELECTRIC Co., a corporation organized under the laws of the State of Ohio, United States of America, of 5 3620, Perkins Avenue, Cleveland, State of Ohio, United States of America).

I, ARTHUR HAROLD STEVENS, a British Subject, of the Firm of Stevens, Langner, Parry & Bollinson, Chartered Patent 10 Agents, of 5/9, Quality Court, Chancery Lane, London, W.C.2, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained 15 in and by the following statement:—

This invention relates to electric motors of the oscillating armature type and more particularly to driving motors for electric dry shavers or the like.

20 Heretofore various types of oscillating armature motors have been employed in dry shavers. In a number of these prior devices an electro-magnet has been used with an armature mounted to oscillate 25 relative to the core of the magnet and to be attracted toward the magnet pole for movement in one direction and to be moved in the opposite direction by spring means. When an alternating current is 30 employed to energize the magnet the armature vibrates or oscillates with a frequency equal to twice the frequency of the applied current. If the usual commercial 35 are employed the resulting number of complete armature oscillations will be 100 or 120 per second. This high speed is objectionable because it creates excessive vibration in the device due to the rela- 40 tively heavy armature cross-section needed in order to conduct the magnetic flux required for satisfactory power. Furthermore this mass of material oscillating at a rate of 120 per second may produce 45 objectionable vibration and noise in the relatively small dimensions which are practical in a device such as a dry shaver or clipper. As the oscillating armature is connected directly to the moving cutter 50 of the device, the high speed of oscillation is also undesirable because it causes relatively rapid wear of the cutter parts and

is not required for satisfactory cutting.

Tests have demonstrated that a rate of 50 or 60 oscillations per second is highly 55 satisfactory in a dry shaver as this speed is fast enough to avoid pulling when the cutters are moved over the skin with a normal rate of movement. As the size of the vibrating armature required for the 60 lower frequency operation is substantially the same as that necessary for the higher frequencies, it will be seen that the undesirable vibration and wear may be greatly reduced by using the 60 per second 65 speed.

In addition to oscillating motors which operate at twice the frequency of the applied current, various other types of 70 motors including rotary electric motors have been proposed and used. These, however, are not entirely satisfactory for dry shaver use because they require make and break contacts, brushes, etc., and provide rotary motion which must be trans- 75 lated into oscillating motion of the cutter blade.

One of the objects, therefore, of the present invention is the provision of an oscillating type electric motor in which 80 the armature oscillates at substantially the frequency of the applied alternating electrical current.

According to this invention there is provided an electric motor of the oscillating 85 armature type adapted to operate on alternating current, comprising a field structure, an armature having a rate of vibration tuned substantially to the frequency of the alternating current supply 90 and supported for oscillating movement with respect to the field structure from a mid-position of maximum reluctance into positions of minimum reluctance, adjacent pole portions on the armature 95 and field structure one of which is divided into spaced salient faces having like strength and polarity at any given instant and the other of which has one less salient face than the divided pole portion 100 whereby each succeeding half cycle of energizing alternating current urges the armature in the opposite direction from the preceding half cycle. The armature

[Price 1/-]

Price 3s. 6d.

Price 4s. 6d.

spring is arranged so that the salient face or faces of one pole portion are disposed between salient faces of the other pole portion when the motor is idle. The 5 spring is arranged so that the motor is self-starting under all conditions. The motor is extremely sturdy in its mechanical and electrical construction and thus requires a minimum of service even after 10 long periods of use, and has a thin disk-like form particularly suited for embodiment in a dry shaver.

The construction and advantages of motors embodying the invention will 15 appear in greater detail from the following description of several embodiments thereof, reference being had to the accompanying drawings in which

Figure 1 is a cross-sectional side view of 20 a preferred embodiment of a motor embodying the invention taken on line 1-1 of Figure 3, the armature being illustrated in the position it assumes when the motor is not operating;

Figure 2 is a view similar to Figure 1 but illustrating the armature at another position in its oscillating stroke;

Figure 3 is an end elevation of the motor shown in Figure 1;

Figure 4 is a fragmentary cross-sectional view taken on line 4-4 of Figure 1;

Figure 5 is a detached perspective view of the armature of the motor shown in 35 Figure 1;

Figure 6 is an illustrative diagram showing the relation of the alternating magnetic field to the movement of the armature;

Figure 7 is a horizontal cross-sectional view taken on line 7-7 of Figure 3;

Figure 8 is a view generally similar to Figure 1 but illustrating a modified form of the motor;

Figure 9 is a view generally similar to Figure 1 but illustrating another modification of the oscillating motor.

In Figures 1 to 7 the field core is generally indicated at F and comprises a plurality of laminations 1 secured together, as by rivets 2 and 3, to build up a core which may be termed generally U-shaped in side elevation. A pair of side plates 4 and 5 are secured on opposite sides 50 of the core F and are spaced therefrom by washers 6. These plates 4 and 5 extend across the open end of the field core and are secured in position by the rivets 3 as is clearly seen in Figures 1 and 3.

The end faces 7 and 8 of the core F are curved on a radius about the armature shaft 9 which extends through and is supported by the side plates 4 and 5. The pendulum type laminated armature, 65 generally indicated at A, is pivotally

supported on the shaft 9 and has curved surfaces 10 and 11 closely adjacent to but not contacting the core faces 7 and 8.

The field coil C is preferably wound to have a generally rectangular inner opening (see Figure 7) and fits into the central opening in the generally U-shaped field core F. The armature A projects from its pivotal support 9 into the interior of the coil C and its lower end 12 forms a pole 75 face as will be later described. It will be seen from Figure 5 that the outer laminations on each side of the armature A extend up beyond the inner laminations on the opposite sides of the bearing portion 13 from the pole face 12. These projecting ends 14 and 15 are formed with angular bearing points 16 and 17 and support the driving member 18, which is preferably of fibre or other similar 85 material and is locked into position between the extending ends 14 and 15 of the armature A by the lugs 19 which project through suitable holes in the ends 14 and 15. The armature assembly is held together in any suitable manner as by rivets 20.

Extending across between the side plates 4 and 5 are the adjusting screw supports 21 and 22 which are preferably of 95 non-magnetic material and may be secured in position between the plates 4 and 5 by projecting lugs which extend through suitable holes in the plates 4 and 5 and are riveted over as seen at 23 and 24 100 in Figure 3.

A coil spring 25 is disposed between an abutment disk 26 and an abutment plate 27, the disk 26 having a depressed portion 28 (see Figure 4) into which the pointed 105 end 29 of the spring adjusting screw 30 extends and which also serves to locate the spring end. In order to provide adjustment of the spring 29 the adjusting screw 30 is threaded through the support 21 and 110 a lock-nut 31 is employed to retain the screw 30 in adjusted position. The abutment plate 27 is of elongated form and includes a depressed portion 32 and a transversely extending V-groove 33. As 115 is clearly seen, Figures 1 and 2, the angle of the opening of the transversely extending V-groove is greater than the angle of the pointed bearing portions 17 of the extending sides 14 and 15 of the 120 armature A and thus the abutment plate 27 provides a pair of bearing points whereby oscillating of the armature A about its pivot shaft 9 is permitted without undesirable distortion of the spring 25 125 and an extremely simple and effective connection is provided between the spring and the armature A.

The opposing spring 34 is mounted on the opposite side of the armature A from 130

the spring 25. An adjusting screw 35 is threaded through the supporting bar 22 and a locknut 36 serves to lock the screw 35 in adjusted position. At the lower end of the spring 34 is an abutment disk 37 and an abutment plate 38 is employed at the upper end of spring 34. These are substantially identical with the disk 26 and plate 27 and function in exactly the same manner.

From the above description it will be seen that the pendulum armature A is adapted to swing about its pivotal support 9 within the coil C against the resistance imposed by the springs 25 and 34. The bottom pole face 12 of the armature A is adjacent the spaced salient faces 39 and 40 of the field core F. These salient points or faces are separated by an opening 41 and are of like polarity when the field core is energized by current passing through the coil C. Thus, the lower end of the armature A forms one pole which is opposed by another pole on the core F which second pole is divided into spaced salient points or faces 39 and 40.

The spring 34 is preferably so constructed as to offer greater resistance to movement of the armature A in clockwise direction (Figure 1) than the spring 25 offers against movement of the armature A in counter-clockwise direction. The advantages of this arrangement will appear from the following explanation of the operation of the motor, it being understood that Figure 1 illustrates the positions of the parts when the current is turned off and the coil C and field F are not energized. The screws 30 and 35 are preferably so adjusted that the lower end 12 of the armature remains in a position closer to the salient face 39 than to the salient face 40. The point  $x$  on the armature A in Figure 1 represents a point on the center line of the armature and it will be seen that it is disposed on the left-hand side of the vertical centre line 42 of the core F. The space or air gap between the corner 12a of the pole face 12 of the armature and the salient face 39 is indicated at 43 while the space or gap between the other salient face 40 and the corner 12b of the armature A is indicated at 44.

When an alternating current of, for example, 60 cycle frequency is applied to the coil C through suitable conductors (not shown) the first increase of the alternating magnetic field to its maximum point will cause the armature A to move toward the salient face 39 due to the attraction between the proposed poles 12 and 39. As the armature is biased to the left or toward the salient face 39 by the adjustment of the springs 25 and 34 the first movement of the armature will

always be to the left when the current is initially turned on. This occurs because the gap 43 is smaller than the gap 44. Movement of the armature A to the left will compress the spring 34 and permit the spring 25 to expand. When the magnetic field falls to zero after reaching its maximum, the compressed spring 34 will move the armature A in counter-clockwise direction and, due to the inertia of the armature and the velocity imparted thereto by the spring, the center thereof will swing across the vertical center line 42 in a position approximately as shown at  $y$  in Figure 2.

As the magnetic field increases to a maximum during the next half cycle, the armature A will be attracted toward the salient face 40 and when the motor is in operation the action will be as illustrated in Figure 6 during each complete alternation of the applied current. Thus, the armature will move from point  $x$  to point  $a$  during the first 90° of a cycle. During the next 90° while the magnetic field decreases from maximum to zero, the spring 34 will move the armature from the point  $a$  to the point  $y$  (shown in Figure 2). As the field increases again to a maximum at 270° the center of the armature will move from point  $y$  to the point  $b$  and as the field again falls to zero, completing the cycle of 360° as shown in Figure 6, the armature will be returned by the spring 24 from the point  $b$  back to its starting point at  $x$ . This oscillation of the armature will continue for as long as the current is applied and it will be seen that a complete stroke of the armature from  $x$  back again to  $x$  is completed in a single cycle of the applied current, each succeeding half cycle of the current urging the armature in the opposite direction from the preceding half cycle. Thus, with 60 cycle current, the armature will swing at 60 complete oscillations per second and, correspondingly, with 50 cycle current, would oscillate at 50 oscillations per second.

The springs 25 and 34 are so designed with respect to the mass of the armature A, and so adjusted by means of the screws 30 and 35 that the natural rate of vibration of the armature is substantially the same as the frequency of the applied current. By advancing or withdrawing the screws 30 and 35, the normal period of vibration of the armature A can be adjusted to suit the current with which the device is to be used. When the motor is first started, the armature may not swing through its full stroke for several cycles but, due to the fact that the initial movement must be against the relatively strong spring 34, it will pick up and

operate at its normal amplitude within a very few cycles.

The motor may be made with the springs 25 and 34 substantially identical and will operate satisfactorily when so constructed. However, by making the springs of different strengths, the initial setting of the armature A to one side of the center line between the salient faces 39 and 40 is not as critical as with equal springs and, in fact, the motor will be self-starting and will operate when the unequal springs are used, even though the armature be substantially on the center line when the current is applied. This will occur because of the unequal resistance to movement of the armature which will permit it to start and pick up full amplitude after several cycles.

In Figures 1 and 2 the extreme positions of the armature A are indicated in dot and dash lines while the full line positions are approximately those of the armature when the magnetization passes through zero. The spacing of the salient faces 39 and 40 of the field pole is such that the pole face 12 of the armature A will be disposed between the two salient faces in its normal stationary position. The strength of the springs 25 and 34 plus the damping of magnetic pull as the armature face overlaps the field pole face control the amplitude of the oscillating stroke of the armature and these springs prevent the armature from striking the coil C at the extreme ends of the stroke. Thus, it will be seen that the operation of the motor is substantially noiseless as there are no make and break contacts and no impact engagement of any parts.

Although the motor is not illustrated as incorporated in an electric shaver, it will be understood by those skilled in the art that the driving element 18 may be connected to the moving cutter blade of such a shaver. Due to the disk like form of the motor, the entire shaver unit may be housed in a flat, easily held casing.

Figure 8 illustrates a modified form of the invention in which the field core F<sup>1</sup> is generally U-shaped but is provided with a pair of energizing coils 45 and 46 wound around the side portions 47 and 48 of the core. Armature supporting side plates 49 are mounted on opposite sides of the core F<sup>1</sup> and extend across the open end thereof in the same manner as plates 4 and 5 in Figure 3. Extending across between the plates 49 is a shaft 50 which supports the armature A<sup>1</sup>. The springs 51 and 52 are similar to springs 25 and 34 and as they are supported and function in substantially the same manner, the details of the adjusting screws need not again be explained.

At the closed end of the core F<sup>1</sup> a projecting pole 53 extends upwardly toward the lower end of the armature A which is formed with a cut-away portion 54 to form spaced salient faces 55 and 56. Thus, in this embodiment of the invention the spaced salient faces are formed on the moving armature and the opposed pole member is on the stationary field. The springs 51 and 52 are preferably so adjusted that in the normal or de-energized position the armature center is disposed at x', on the left-hand side of the core center line 57 and the gap 58 between the pole 53 and salient point or face 55 is smaller than the gap 59 between the pole 53 and salient faces 56.

The operation of the motor of Figure 8 is substantially the same as that of the motor previously described, i.e., when alternating current is applied to the coils 45 and 46, which are preferably arranged in series, the armature A<sup>1</sup> swings to the left because of the attraction between the pole 53 and the nearest salient face 55. After the armature picks up its full amplitude of oscillation, the movement is substantially the same as that of the armature A in Figure 1. This construction is particularly well adapted for relatively heavy duty motors as it permits an armature of greater cross-sectional area to be employed.

Another modification of my improved oscillating motor is shown in Figure 9 in which the field core F<sup>11</sup> is also generally U-shaped but the armature A<sup>11</sup> is double-ended rather than of pendulum form. Side plates 60 extend across the open end of the field F<sup>11</sup> and the shaft 61 supports the double-ended armature A<sup>11</sup>. Plates 62 extend at right angles to the armature A<sup>11</sup> and are secured thereto. These plates carry the driving member 63 at their upper ends and are formed with bearing points 64 and 65 adjacent their lower ends. The springs 66 and 67 are mounted between abutment plates in the same manner as previously described and adjusting screws 68 and 69 are threaded through transversely extending supporting bars 70 and 71. In order to obtain the advantages of the unbalanced spring arrangement the spring 66 is preferably stiffer than spring 67. Wound around the bottom closed portion of the U-shaped core F<sup>11</sup> is an energizing coil 72 and each end of the armature A<sup>11</sup> is disposed adjacent spaced salient points or faces on the core F<sup>11</sup>. The end 73 of the armature is normally located between the salient faces 74 and 75 which are of like polarity. In like manner, the end 76 of the armature A<sup>11</sup> is disposed between the salient faces 77 and 78 and the springs 66 and 130

67 are so adjusted that in de-energized position the armature is closest to the salient faces 74 and 78, the gap 79 being smaller than the gap 80. When current is supplied to the coil 72, the salient faces 74 and 78 act together to urge the armature A<sup>11</sup> in clockwise direction. By properly tuning the period of oscillation of the armature by means of the springs 66 and 67 and the mass of the armature, the armature will oscillate in step with and at the same rate as the frequency of the applied current.

The adjustable springs permit tuning the period of oscillation of the armature so that it is equal substantially to the frequency of the applied current so that the same motor may be adjusted for use with current supplied of different frequency. Between each rise of the field strength to its maximum value the armature will swing across its mid-position so that each increase in field strength to a maximum will exert a force on the armature urging it in a direction opposite to that of the preceding high point in the field strength.

Although the illustrated embodiments of the invention have been described in considerable detail, it will be understood by those skilled in the art that various modifications and variations might be made in the specific arrangement of parts employed. The invention, therefore, is not limited to the particular embodiments herein shown and described.

Having now particularly described and ascertained the nature of my said invention (as communicated to me by my foreign correspondents), and in what manner the same is to be performed, I declare that what I claim is:—

1. An electric motor of the oscillating armature type adapted to operate on alternating current, comprising a field structure, an armature having a rate of vibration tuned substantially to the frequency of the alternating current supply and supported for oscillating movement with respect to the field structure from a mid-position of maximum reluctance into positions of minimum reluctance, adjacent pole portions on the armature and field structure one of which pole portions is divided into spaced salient faces having like strength and polarity at any given instant and the other of which pole portions has one less salient face than the divided pole portion whereby each succeeding half cycle of energizing alternating current urges the armature in the opposite direction from the preceding half cycle.

2. A motor according to claim 1, wherein a salient face of the pole portion having the lesser number of salient faces is normally disposed between the spaced salient faces of the divided pole portion when the coil is deenergized.

3. A motor according to any one of the preceding claims, wherein the armature is biased for initial movement in one direction when a coil pertaining to the field structure is energized.

4. A motor according to any one of the preceding claims, wherein spring means are provided for resisting oscillating movement of the armature in both directions, the spring means offering greater resistance to movement of the armature in one direction than in the other direction.

5. A motor according to any one of the preceding claims, comprising an energizing coil mounted on the field structure and surrounding at least part of the armature.

6. A motor according to any one of the preceding claims, wherein the core of the field structure is generally U-shaped.

7. A motor according to claim 6, having its energizing coil disposed in the opening between the legs of the U-shaped core.

8. A motor according to claim 6 or 7, wherein the field structure is provided with spaced salient pole portions adjacent its closed end.

9. A motor according to any one of claims 6 to 8, wherein the armature is pivotally supported between the open ends of the U-shaped core of the field structure.

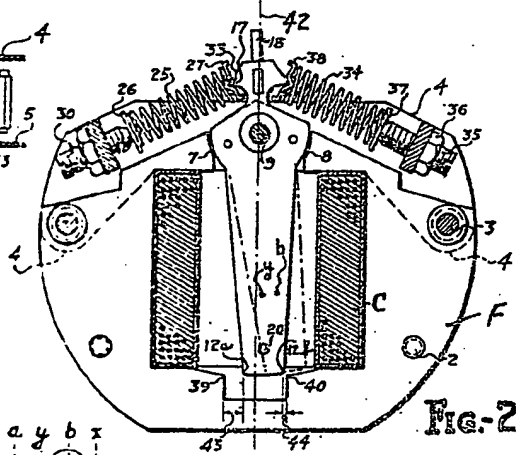
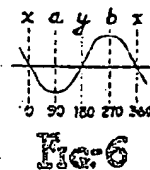
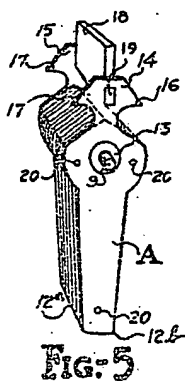
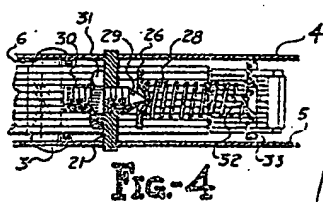
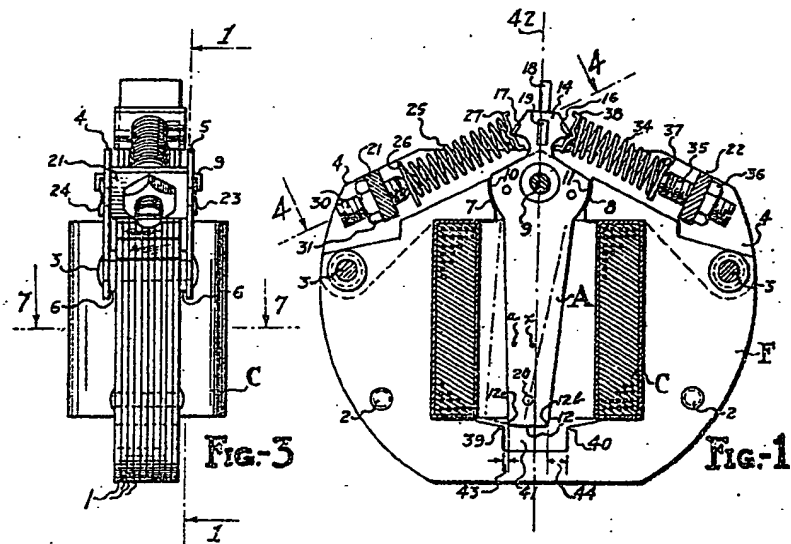
10. A motor according to claim 6, wherein the spaced ends of the legs of the U-shaped core constitute pole portions both of which are provided with spaced salient faces, and wherein a double-ended armature is mounted in the space between said pole portions, each end of the armature having a salient face for coaction with the spaced salient faces of the adjacent pole portion of the core.

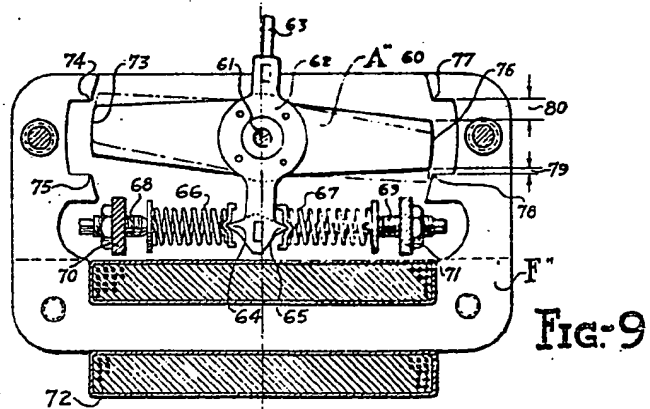
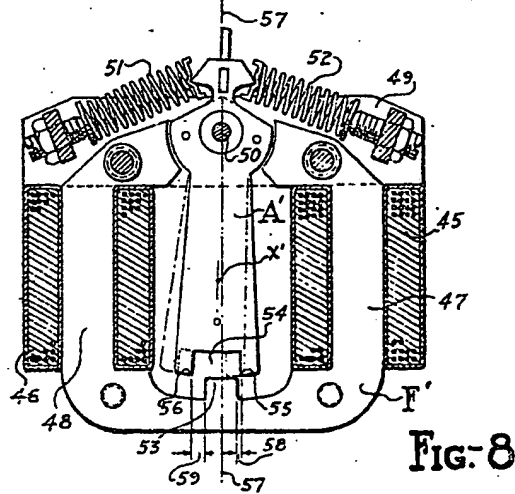
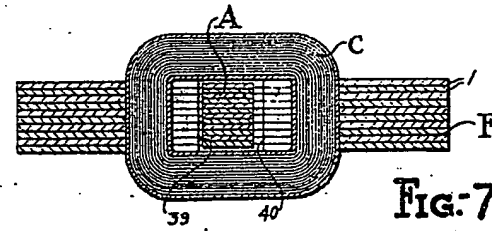
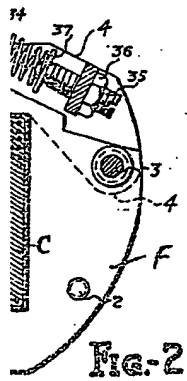
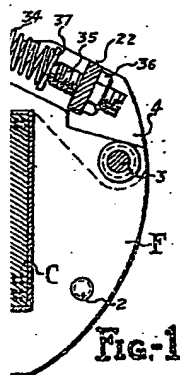
11. A motor substantially as hereinbefore described, with reference to Figs. 1 to 7 or Fig. 8 or Fig. 9 of the accompanying drawings.

Dated this 27th day of April, 1944.

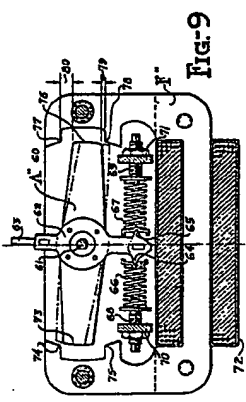
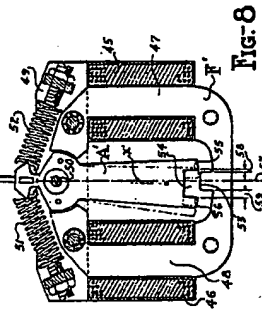
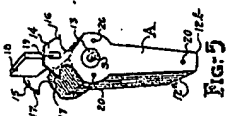
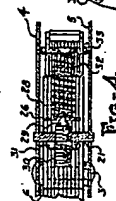
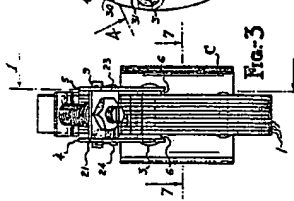
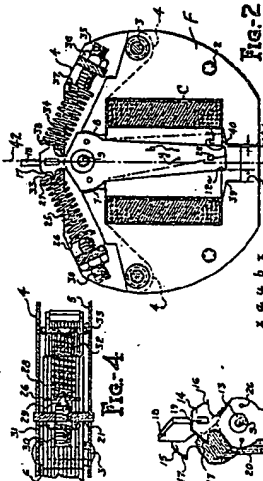
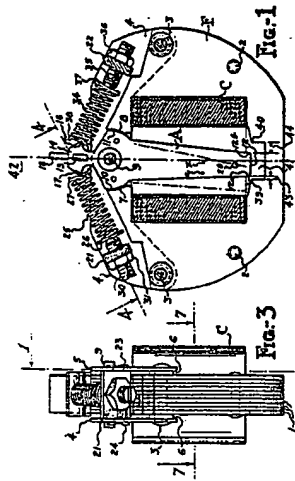
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